(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number : **0 541 324 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number : **92310044.0**

(22) Date of filing : **03.11.92**

(51) Int. Cl.[5] : **F25B 5/02,** F25D 11/02, F25B 1/10

The application is published incomplete as filed (Article 93 (2) EPC). The point in the description or the claim(s) at which the omission obviously occurs has been left blank.

(30) Priority : **04.11.91 US 787080**

(43) Date of publication of application : **12.05.93 Bulletin 93/19**

(84) Designated Contracting States : **DE ES FR GB IT SE**

(71) Applicant : **GENERAL ELECTRIC COMPANY**
1 River Road
Schenectady, NY 12345 (US)

(72) Inventor : **Herbst, Leroy John**
10732 Trappers Creek Drive
Raleigh, North Carolina 27600 (US)
Inventor : **Jacobus, Dwight William**
2230 Hawthorne Avenue
Louisville, Kentucky 40205 (US)
Inventor : **Payton, Willard Eugene**
3712 Marvin Avenue
Louisville, Kentucky 40218 (US)

(74) Representative : **Pratt, Richard Wilson et al**
London Patent Operation G.E. Technical Services Co. Inc. Essex House 12/13 Essex Street
London WC2R 3AA (GB)

(54) Refrigeration systems.

(57) A household refrigerator (10) includes a refrigerant system with separate freezer and fresh food compartment evaporators (20,21). The evaporators are connected in parallel refrigerant flow relationship so that refrigerant flowing from the condenser (22) can flow through either evaporator to the compressor (23) independent of the other evaporators. A selected section (33) of refrigeration conduit for each evaporator is arranged in heat transfer relationship with a selected section of refrigeration conduit for the other evaporator.

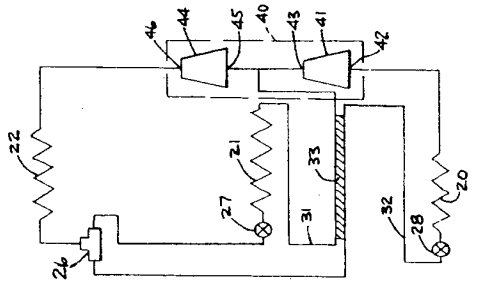

FIG. 2

EP 0 541 324 A1

The present invention relates generrally to refrigeration systems and, for example to household refrigerators.

This application is related to U.S. Patent Nos. 4,910,972 and 4,918,942 issued to Heinz Jaster and assigned to General Electric and EP-A-485146 (USSN 07/612,290) and each of which is incorporated herein by reference.

A typical present day household refrigerator includes a refrigeration system which circulates refrigerant continuously through a closed circuit including a compressor, a condenser, an expansion device (normally in the form of a capillary tube), and an evaporator back to the compressor. The refrigerant is a two-phase material having a liquid phase and a vapor phase. The refrigeration system operates to cause the refrigerant to repeatedly change from a liquid to a vapor and back to a liquid to transfer energy from inside the refrigerator by removing heat from the refrigeration compartments and expelling it to the atmosphere outside the refrigerator. In a typical refrigerator the evaporator is mounted in the freezer and a fan blows air across the evaporator with the air stream being split so that most of it circulates within the freezer but a portion of it is diverted to circulate through the fresh food compartment. In this way the freezer typically is maintained between -10°F and +15°F while the fresh food compartment is maintained between +33°F and +47°F. Such refrigerators do not operate at maximum possible efficiency as the refrigeration cycle produces its refrigeration effect at a temperature which is appropriate for the freezer, but is lower than is required to maintain the fresh food compartment at its appropriate temperature. The mechanical energy required to produce cooling at lower temperatures is greater than that required to produce cooling at higher temperatures and thus the typical simple vapor compression cycle uses more mechanical energy than one which produces cooling at two temperature levels.

Each of U.S. Patents 4,910,972 and 4,918,942 each discloses a refrigeration system in which a separate evaporator is used to provide the refrigeration for each of the freezer and fresh food compartments. The compressor or compression means in each of these patents takes the form of a two-stage compressor or dual compressors. Refrigerant from the freezer evaporator is fed to a low pressure stage which elevates its pressure to an intermediate level. The vapor stage refrigerant from the fresh food compartment is combined with the refrigerant exiting the low pressure compression stage and all,the recirculated refrigerant is then fed to a high pressure compression stage, which raises the refrigerant pressure to the desired relatively high compressor outlet pressure.

EP-A-485146 discloses refrigeration circuits utilizing separate evaporators for the freezer compartment and the fresh food compartment. It discloses the use of a compression means combining single stage compressor with a valve which selectively connects the outlet of the freezer evaporator and vapor stage refrigerant from the fresh food compartment alternately to the single compressor. Thus, when the valve feeds refrigerant from freezer evaporator to the compressor, the compressor raises the refrigerant pressure all the way from the low pressure of the evaporator freezer to the desired high compressor outlet pressure. On the other hand, when the valve feeds vapor refrigerant from the fresh food evaporator to the compressor, the compressor only has to raise the pressure from an intermediate pressure level to the desired compressor outlet pressure.

Each of the above-described related patents and application connect the fresh food evaporator and the freezer evaporator in series relationship in the refrigerant flow circuit, with a phase separator connected between them. The phase separator functions to separate vapor stage refrigerant and liquid stage refrigerant with the liquid refrigerant being fed to the freezer evaporator and the vapor refrigerant being fed to the compressor means. In each of these refrigerant circuits, it is possible that, when the fresh food compartment needs substantial cooling, the fresh food evaporator will cause at least the vast majority of the refrigerant to vaporize. Thus, there may be insufficient liquid refrigerant in the phase separator to appropriately feed the freezer evaporator resulting in that evaporator being °"starved" and the freezer receiving insufficient cooling.

Embodiments of the present invention seek to provide:

a refrigerator including an improved refrigerant system;

a household refrigerator with separate evaporators for the fresh food compartment and thee freezer compartment in which the flow of refrigerant through each of the evaporators is independent of the flow of refrigerant through the other evaporator; and/or

a household refrigerator in which a plurality of evaporators are connected in parallel refrigerant flow relationship with each other in a unitary refrigerant circuit.

SUMMARY OF THE INVENTION

In one aspect of the present invention a household refrigerator comprises compressor means, condenser means connected to receive refrigerant discharged from the compressor means, a fresh food compartment with a fresh food evaporator for refrigerating the fresh food compartment and a freezer compartment with a freezer evaporator for refrigerating the freezer compartment. The fresh food and freezer evaporators are connected in parallel refrigerant flow relationship between the condenser means and the compressor means so that refrigerant exiting

the condenser means may flow through either of the evaporators to the compressor means independent of flow of refrigerant through the other of the evaporators.

The invention, both as to organization and method of practice, may best be understood by reference to the following description taken in conjunction with accompanying drawings in which :

FIG. 1 is a simplified schematic side elevational representation of a household refrigerator incorporating one form of the present invention;

FIG. 2 is a schematic diagram of another refrigerant circuit incorporating the present invention and suitable for use in a household refrigerator;

FIG. 3 is a schematic diagram of another refrigerant circuit incorporating a form of the present invention and suitable for use in a household refrigerator;

FIG. 4 is a schematic diagram of yet another refrigerant circuit incorporating one form of the present invention and suitable for use in a household refrigerator; and

FIG. 5 is a simplified schematic side elevational view of a household refrigerator including a refrigerant circuit incorporating another form of the present invention.

form a household refrigerator 10 including an insulated outer wall 11 and an insulated dividing wall 12, separating the refrigerator into a freezer compartment 13 and a fresh food compartment 14. Doors 15 and 16 provide access to the interior of the freezer and fresh food compartments respectively. Below the fresh food compartment there is a machinery or equipment compartment 17 which houses various operating components of the refrigerator.

Typically, the refrigeration system of a present day household refrigerator is operated so that the freezer compartment is maintained in a temperature range between -10°F and +15°F while the fresh food compartment is maintained in a temperature range between about +33°F and +47°F, respectively. The refrigeration system for the refrigerator 10 includes a first or freezer evaporator 20, a second or fresh food evaporator 21, a condenser 22 , and a compressor or compression means 23. These basic units are connected together by conduit in a fluid and vapor tight refrigerant circuit for circulation of two phase refrigerant, as is well known in the art. More specifically, the compressor 23 is of the two stage type having a first or low pressure compression stage and an upper or high pressure compression stage. The high pressure refrigerant gas or vapor exits the compressor 23 from an outlet 24 and flows to the condenser 22 where it is changed from a gas to a liquid. From the condenser 22 the liquid refrigerant flows through a dryer 25 to a valve or joint 26 which divides the refrigerant flow into two parallel refrigerant paths. A first path extends through an expansion device 27 to the fresh food evaporator 21 and then back to the intermediate pressure inlet 28 of the compressor. The other refrigerant flow path from the Joint 26 extends through an expansion device 29 to the freezer evaporator 20 and then back to a low pressure inlet 30 of the compressor.

It will be understood that the expansion means or devices 27 and 29 may take any one of a number of known configurations. In a typical household refrigerator this expansion device is in the form of a capillary tube which allow the refrigerant to expand and begin to convert from a liquid to a vapor as it passes through the capillary tube. Other kinds of refrigeration systems use expansion valves, either preset or adjustable, to permit the refrigerant to expand. Such valves also can be used in household refrigerators; however, capillary tubes are preferred for such applications as they are less expensive.

In a refrigerator with separate freezer and fresh food evaporators the freezer evaporator 20 operates at a significantly lower temperature than the fresh food evaporator 21. Therefore, the vapor or gaseous refrigerant flowing from the evaporator 20 to the compressor 23 is at a significantly lower pressure than the refrigerant flowing from the evaporator 21 to the compressor. The refrigerant from the freezer evaporator is fed to the low pressure inlet 30 of two stage compressor 23 and is compressed by the first or low pressure stage to an intermediate pressure, generally corresponding to the exit pressure of the fresh food evaporator 21. The refrigerant exiting the fresh food evaporator 21 is fed to the intermediate pressure inlet 28 of the compressor 23. The refrigerant from the fresh food evaporator and from the low pressure stage of the conpressor is compressed by the second stage to the relatively high exit pressure of the compressor. Thus, as with the related prior art previously discussed, energy is saved because only the refrigerant necessary to cool the freezer is cycled between low level of the freezer evaporator outlet pressure and the high level of the compressor outlet pressure and the refrigerant used to cool the fresh food compartment is cycled between an intermediate pressure level necessary to provide the desired operating temperature of the fresh food compartment and the high level of the compressor outlet pressure.

In contrast to the previously discussed related prior art, the refrigerant for the freezer evaporator does not flow through the fresh food evaporator. Thus, the fresh food evaporator cannot starve the freezer evaporator for refrigerant and the freezer evaporator is assured of sufficient refrigerant for appropriate operation.

The portion of conduit 31 connecting the outlet of the fresh food evaporator 21 with the compressor and the portion of conduit 32 connecting the valve or Joint 26 with the expansion means 29 are arranged in heat transfer relationship with each other, as indicated at

33. This normally is accomplished either by brazing the two lengths of conduit together in a reverse flow relationship or by wrapping one of the conduits tightly around the other one. This heat transfer relationship results in the relatively cold refrigerant flowing from fresh food evaporator 21 providing pre-cooling and intercooling of the relatively hot refrigerant flowing to the freezer evaporator 20. This intercooling further enhances the efficiency of the system.

A thermostat 35 is mounted in the fresh food compartment and senses the ambient temperature within that compartment. When the thermostat senses a predetermined high temperature, normally in the vicinity of the upper temperature limit of that compartment, such as +47°F for example, it causes the compressor 23 to be connected to a source of power such as the household electric system and the compressor then will continue to run until the thermostat senses a predetermined lower temperature, normally in the vicinity of the lower limit of the operating range of the fresh food compartment, such as +33°F for example. It will be understood that other, more involved control systems, may be used. For example, an additional thermostat that can be placed in the freezer compartment with the thermostats in the freezer and fresh food compartments cooperating to control the operation of the compressor, and thus the refrigeration system. It also will be understood that, for the sake of simplicity, various other components normally included in household refrigerators, such as for example lights and air circulating fans, have been omitted for the sake of simplicity.

It will be understood that the passage of the refrigerant conduits and wiring through the insulated wall 11 is sealed to prevent air leakage. Thus, the openings 37 and 38 are for ease of illustration only.

Fig. 2, illustrates another refrigerant circuit, which is substantially similar to that included in Fig. 1 except for the compression means, and like numerals are used to identify like components. The compression means 40 includes a first, low pressure compressor 41 having an inlet 42 and an outlet 43, and a second, high pressure compressor 44 having an inlet 45 and an outlet 46. The compressors 41 and 44 may be independent of each other with each being operated by its own motor but are controlled so that they operate simultaneously. Alternatively, they may be operated by a single motor as they will always operate at the same time. The refrigerant exiting freezer evaporator 20 is fed to the inlet 42 of low pressure compressor 41 which compresses that refrigerant to an intermediate pressure corresponding to the outlet pressure of the fresh food evaporator 21. Refrigerant from both the low pressure compressor 41 and the fresh food evaporator 21 is fed to the inlet of the high pressure compressor 44, which compresses the combined refrigerant to a high pressure. This high pressure refrigerant flows from exit 46 of the compressor 44 is fed to the condenser 22.

Fig. 3 illustrates another refrigerant circuit which is substantially similar to that of Figs. 1 and 2, except that it uses a compression means including a valve and a single compressor, and the same numerals have been used identifying like components. A flow control or selection valve 50, having a pair of inlets 51 and 52 and an outlet 53, is connected between the outlets of the evaporators 20 and 21 and the inlet of a single stage compressor 54. The valve 50 functions to alternately connect each of evaporators 20 and 21 to the inlet of the compressor 54 so that, so long as the compressor 54 is operating, the valve 50 alternately conducts refrigerant from each of the evaporators 20 and 21 to compressor 54. When compressor 54 is connected to evaporator 20 it compresses refrigerant from the relatively low exit pressure of evaporator 20 to the high exit pressure of the compressor whereas, when compressor 54 is connected to evaporator 21 it compresses refrigerant from an intermediate pressure to the same compressor outlet pressure. Details of construction, operation and control of valves suitable for use in this circuit are shown and described in co-pending application EP-A-485146 (USSN 07/612,290) incorporated herein by reference. It will be understood that a two stage compressor 23 as illustrated in Figs. 1 and 6, a compression means such as 40 including two separate compressors 41 and 44 as illustrated in Figs. 2 and 4; and a compression means including a valve 50 and compressor 54 arrangement, as shown in Fig. 3, may be utilized essentially interchangeably with various embodiments of the present invention.

Fig. 4 discloses a refrigerant circuit similar to those of Figs. 1 and 2, except for the location of the heat exchange relationship between the freezer and fresh food conduits for intercooling of refrigerant flowing to the freezer evaporator, and like numbers have been used to identify like parts. In Fig. 4 the conduit portion 56 connected between the expansion device 27 and the inlet of the fresh food evaporator 21 is arranged in heat exchange relationship with the conduit portion 32 connecting the valve 26 to the expansion device 28 for freezer evaporator 20, as indicated at 57. In addition, the conduit portion 58 connecting the outlet of freezer evaporator 20 to the compressor means 40 also is disposed in heat exchange relationship with the conduit portion 32, as indicated at 59. This double heat exchange relationship more completely uses the cooling capability of the refrigerant in the system, and thus enhances efficiency.

In the previously described embodiments, portions of the conduit carrying refrigerant for the two evaporators are arranged in heat transfer relationship with each other to provide intercooling for the refrigerant flowing to the freezer evaporator. In the embodiment illustrated in Fig. 5, this intercooling of the freezer evaporator refrigerant is provided in a somewhat

more indirect manner. To this end, an intercooler or heat transfer device 62 is connected in refrigerant flow relationship between the joint or valve 26 and the freezer refrigerant expansion means 28 and is positioned in the fresh food compartment 14, preferably near the fresh food evaporator 21. With this arrangement the refrigerant passing through the intercooler 62 is cooled by the air in fresh food compartment 14, an action of the fresh food evaporator. Conveniently, the intercooler 62 may be constructed as a small heat exchanger like an evaporator or a condenser. Other aspects of the refrigerator are substantially similar to the embodiment illustrated in Fig. 1, and like numbers have been used to identify like compartments.

Claims

1. A refrigerator comprising:
compressor means;
condenser means connected to receive refrigerant discharged from said compressor means;
a fresh food compartment, a fresh food evaporator for refrigerating said fresh food compartment;
a freezer compartment, a freezer evaporator for refrigerating said freezer compartment;
said fresh food and said freezer evaporators being connected in parallel refrigerant flow relationship between said condenser means and said compressor means;
whereby refrigerant may flow from said condenser means through either of said evaporators to said compressor means independent of the other of said evaporators.

2. A refrigerator as set forth in Claim 1, including precoding means effective for utilizing the cooling effect of refrigerant flowing through said fresh food evaporator to extract heat from refrigerant flowing from said condenser means to said freezer evaporator.

3. A refrigerator as set forth in Claim 1, further comprising: conduit means enabling the fluid flow relationship between said compressor means, said condenser means, said fresh food evaporator and said freezer evaporator respectively and wherein a portion of said conduit means enabling refrigerant flow for said fresh food evaporator and a portion of said conduit means enabling refrigerant flow for said freezer evaporator are arranged in heat transfer relationship.

4. A refrigerator as set forth in Claim 3, further comprising: fresh food refrigerant expansion means connected in refrigerant flow relationship between said condenser means and said fresh food evaporator; and freezer refrigerant expansion means connected in refrigerant flow relationship between said condenser means and said freezer evaporator; and wherein a portion of said conduit means for said fresh food evaporator and position downstream of said fresh food refrigerant expansion means is arranged in heat transfer relationship with a portion of said conduit means for said freezer evaporator positioned upstream of said freezer refrigerant expansion means.

5. A refrigerator as set forth in Claim 5, wherein: a portion of said conduit means connected between said fresh food refrigerant expansion means and said fresh food evaporator is arranged in heat transfer relationship with a portion of said conduit means connected between said condenser means and said freezer refrigerant expansion means.

6. A refrigerator as set forth in Claim 4, wherein: a portion of said conduit means connected between said fresh food evaporator and said compressor means is arranged in heat transfer relationship with a portion of said conduit means connected between said condenser means and said freezer refrigerant expansion means.

7. A refrigerator as set forth in Claim 1, wherein: said precoding means includes subcooler means connected in refrigerant flow relationship between said condenser means and said freezer evaporator and positioned in said fresh food compartment for removing energy from refrigerant flowing through said subcooler.

8. A refrigerator as set forth in Claim 1, wherein: said compressor means includes a low compression stage and a high compression stage, said freezer evaporator is connected to supply refrigerant to said low compression stage and said fresh food evaporator is connected to supply refrigerant to said high compression stage.

9. A refrigerator as set forth in Claim 1, further comprising: refrigerant flow control means connected in refrigerant flow relationship between each of said evaporators and said compressor means and effective selectively to connect an individual one of said evaporators in refrigerant flow relationship with said compressor means at any particular time.

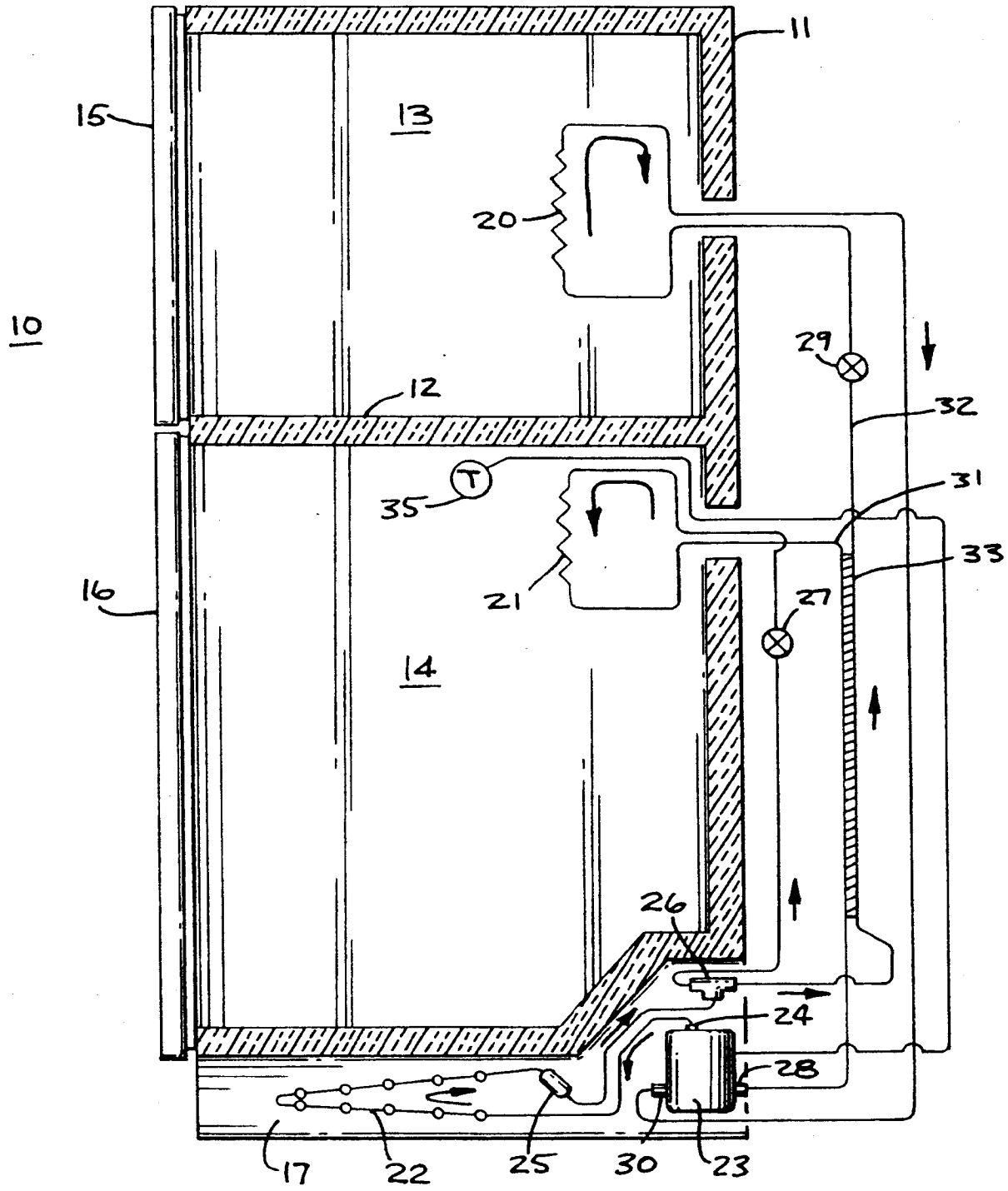

FIG.1

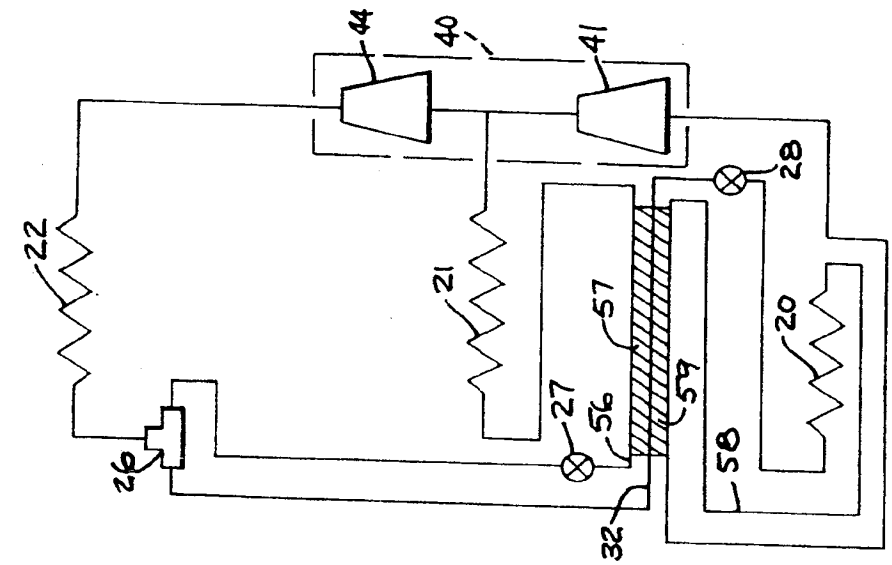

FIG. 4

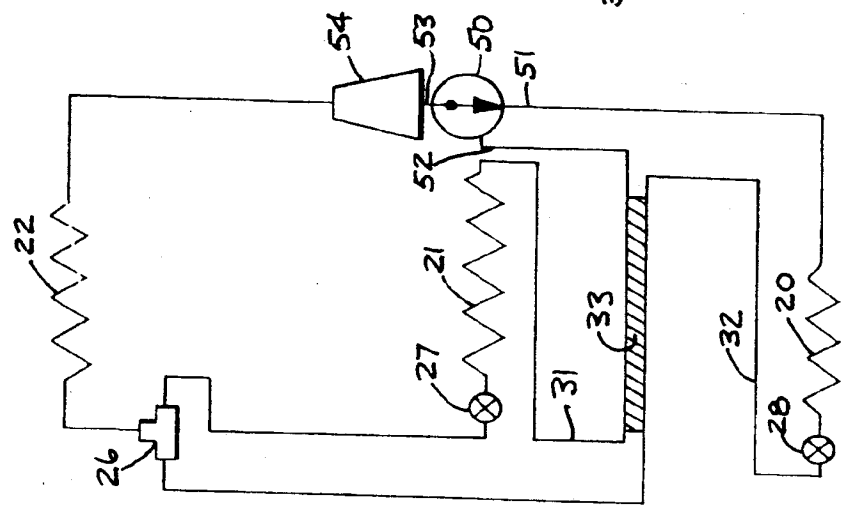

FIG. 3

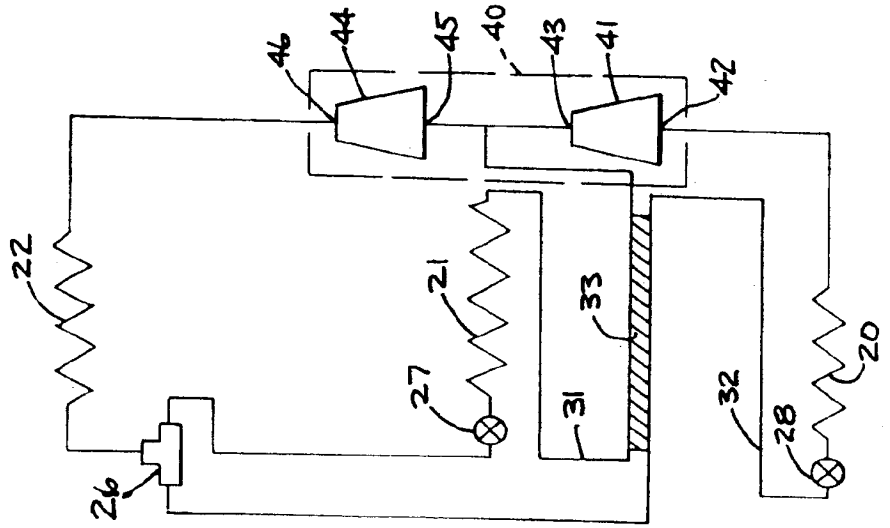

FIG. 2

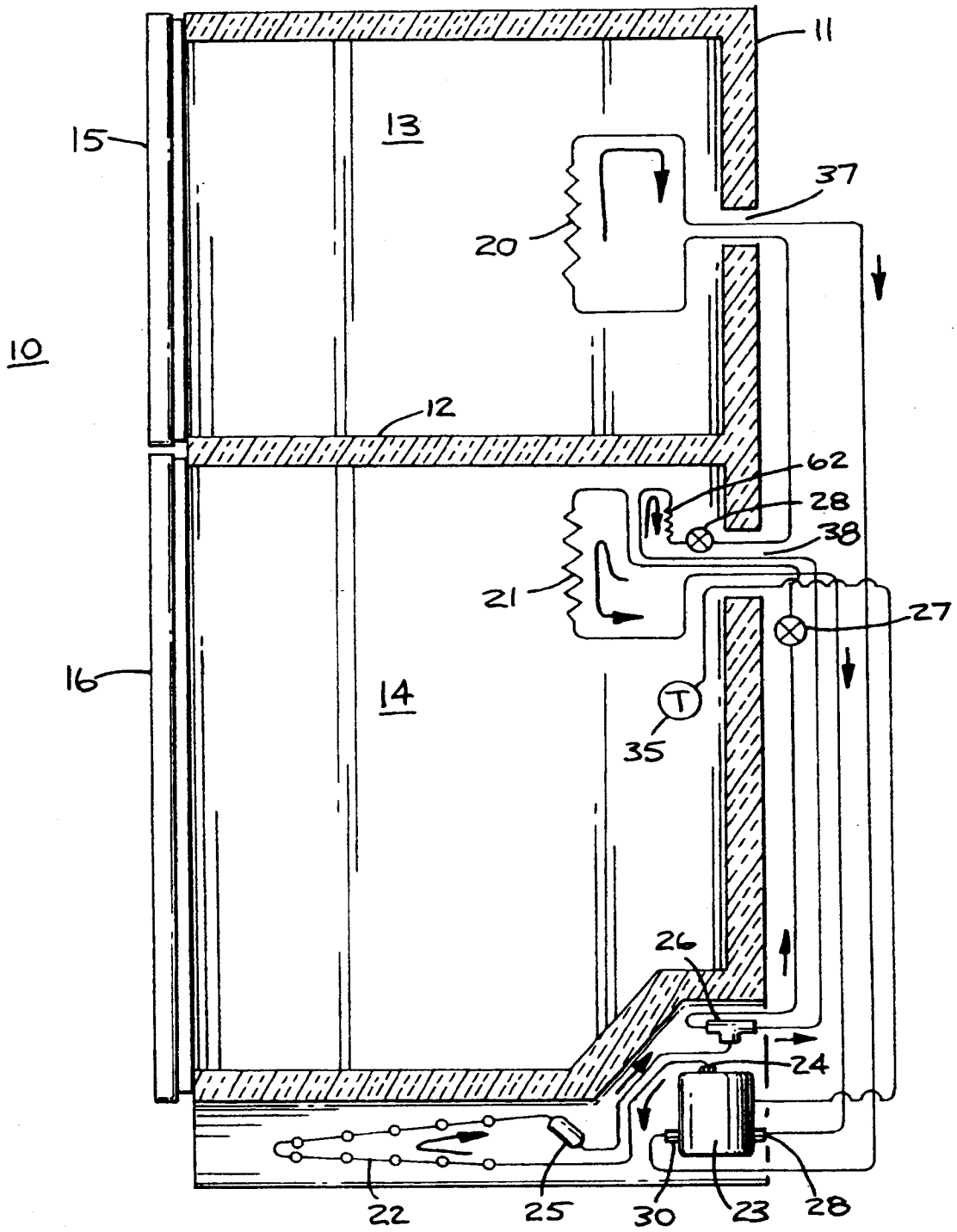

FIG. 5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 92 31 0044

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X Y	US-A-3 226 949 (GAMACHE) * column 2, line 39 - column 7, line 69; figure 1 *	1,8 2-4,9	F25B5/02 F25D11/02 F25B1/10
Y	US-A-2 272 093 (MCCORMACK) * the whole document *	2-4	
Y	GB-A-639 691 (BRITISH THOMSON-HOUSTON) * page 1, line 74 - line 85; figure 1 *	9	
A	US-A-2 228 834 (KRAMER, JR.) * page 2, right column, line 65 - page 3, left column, line 35; figure 2 *	1-4,6	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5) F25B F25D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	03 FEBRUARY 1993	BAECKLUND O.A.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P0401)